INTERSTATE 680 VARIABLE PRICING STUDY

EXECUTIVE SUMMARY

Findings

The proposal to utilize planned high-occupancy vehicle (HOV) lanes on Interstate 680 as combined HOV and high-occupancy toll (HOT) lanes is found to be financially, operationally, and physically feasible. The recommended separation treatment between the HOV/HOT and the adjacent mixed-flow lanes is solid striping, with limited ingress/egress locations for HOV and HOT users. A combination of electronic toll collection, video surveillance and enhanced highway patrol enforcement would assure an acceptably high level of compliance by HOV and HOT users. The HOV/HOT lane system components could be flexibly adjusted as changes in traffic and economic conditions warrant and could be implemented as a pilot project. Revenues generated from the system could be used for improvements on the corridor, including capital improvements and enhanced transit service. However, implementation involves several challenges, primarily institutional rather than technical.

Background & Purpose of the Study

The Interstate 680 Widening Project is being undertaken by the California Department of Transportation (Caltrans) to address needs in a corridor that has experienced significant and rapidly growing traffic congestion in recent years. The corridor is characterized by strongly directional traffic flow, with approximately two-thirds of the morning peak traffic heading southbound and slightly less than two-thirds northbound in the afternoon peak. The peak-periods have been spreading to encompass more hours as traffic volume and congestion have grown substantially, up to 4.5 hours in the AM peak. In 2001, when comprehensive data was last gathered, the average trip time was 2.5 times more than would be the case under free-flow conditions.

The Caltrans project would widen from six lanes to eight lanes the 14-mile segment of I-680 freeway from Route 84 in the north to Route 237 (Calaveras Boulevard) in the south. The Caltrans plan is for the two new lanes to be HOV lanes. An interim southbound HOV lane has been constructed and was opened to traffic in December 2002; the standard southbound lane HOV lane is due for opening in early 2007, and the northbound lane will follow at a later date.

The purpose of this study, sponsored by the Alameda County Congestion Management Agency (ACCMA), is to determine whether adding a HOT lane feature to the HOV lanes is feasible operationally, financially, and physically. The concept of a HOT lane is to allow vehicles otherwise ineligible to use the HOV lane to enter the lane in exchange for paying a toll. The amount of the toll would vary by time of day and demand, while eligible HOVs would continue to use the lane for free. The potential benefits to using a HOT lane would be: (1) Use and manage capacity more efficiently; (2) Influence rational transportation decision-making by travelers by linking congestion impacts to value of time; (3) Provide a new option for travelers; (4) Generate revenues for transportation purposes; (5) Provide a demonstration project of road pricing for the region, with the possibility of replicating it in other HOV locations.

HOT lanes are one form of variable road pricing. HOT lanes are currently operating in three U.S. locations (SR 91 in Orange County, I-15 in San Diego, and I-10 in Houston). Each of those projects has demonstrated the successful combination of HOV lanes with a HOT lane option for those who are willing to pay a toll that varies by time of day and/or traffic conditions. There are more modest forms of variable pricing, with tolls reduced during off-peak hours, in operation in Fort Lee, Florida, and the New York/New Jersey bridges, tunnels and turnpike. Internationally, there are a number of locations that have implemented some form of road pricing that is variable by time of day, including Singapore, Norway, Canada, and the United Kingdom. Most of those

systems are "cordon" schemes, whereby a driver pays a daily fee to enter a center city district during business hours.

Freeway Configuration and Costs

This study looked at a wide range of alternatives at the outset. These included, in addition to the six existing mixed-flow lanes: (1) one HOV lane in each direction (Alternative A); (2) two reversible HOV lanes, one on each side of the freeway (Alternative B), or both in the median (Alternative C); (3) three HOV lanes, one of which would be reversible and in the median separated by fixed barriers(Alternative D); and three HOV lanes, one of which would be reversible in the median, plus one on each side of the freeway separated by a movable barrier (Alternative E). After consultation with Caltrans and the ACCMA, the study eliminated further analysis of the nine-lane and reversible options as infeasible in the near-term. All subsequent financial and operational analysis focused on Alternative A, eight-lanes with one combined HOV/HOT lane in each direction. There will be a buffer with a width in the range of 2 to 4 feet between HOV/HOT lanes and the adjacent mixed-flow lanes; including this buffer is deemed desirable for either HOV-only or HOV/HOT lanes and provides flexibility for future restriping.

The additional cost of changing the freeway configuration for Alternative A to accommodate HOT lanes with an intermediate access location is $4.6- $5.0 million. HOT lanes also require additional toll collection and enforcement costs of approximately $3.2 million capital and $1.0 million for annual operations, but these do not alter the configuration of the freeway.

The key variables studied under Alternative A are:

Lane separation treatments between the HOV/HOT lane and adjacent mixed-flow lanes. Options include (1) physical barriers, (2) simple striping with buffers between HOV/HOT and mixed-flow lanes, and (3) striping with buffers plus plastic pylons. The simple striping option is recommended at this time, because the physical barrier is considerably more expensive and less flexible than striping. The striping alone is preferred to striping plus pylons, due to the maintenance cost of the pylons and Caltrans safety concerns. The ingress/egress locations can be modified easily by simply changing the striping and adding pavement if necessary. If the HOT lane experiment is not successful, it can be discontinued easily and inexpensively.

Number and location of intermediate access to and from the HOV/HOT lanes. Options include (1) continuous, unlimited access (current configuration of Bay Area HOV lanes); (2) limited access for the entire 14-mile corridor with no intermediate ingress/egress points; and (3) limited access with one or more intermediate access points. Based on preliminary findings, an appropriate location for one intermediate access would be in the vicinity of the Route 262 (Mission Boulevard) interchange, approximately the midpoint of the HOT corridor. Permitting continuous access is problematic for a HOT lane, because it makes enforcement and toll collection more difficult if vehicles can move at will in and out of the HOV/HOT lanes. None of the existing HOT lanes in the U.S. have continuous access. Limited access has the advantage of making tolling and enforcement much easier and apparent to law enforcement. However, it is acknowledged that determined toll evasion is easier than it would be with a solid physical barrier. Limited access would also reduce somewhat the number of HOV users of the lanes, because some HOVs would have origins or destinations at a location different from the designated ingress/egress locations.

Effect of carpool eligibility policies. Options include an HOV definition of 2+ or a definition of 3+ persons eligible to use the lanes for free. The analysis considers both options.

Toll collection methods. One option is a "placard" system, consisting of a pass or permit purchased periodically (e.g., monthly) for a fixed price and signified by a placard or decal affixed to the windshield. A second option is electronic toll collection, using technology compatible with the FasTrak system on the region's bridges, whereby an electronic reader identifies the vehicle

from an in-vehicle transponder and deducts the toll from a prepaid account. This study recommends electronic toll collection with a robust collection and enforcement program, including additional highway patrol, extra toll readers and video surveillance cameras for enhanced enforcement and deterrence. Electronic toll collection allows for much more flexibility in adjusting toll levels as needed to assure no overloading of the HOV/HOT lane and substantially more revenue than a permit system. The estimated capital cost of such an electronic collection and enforcement system is approximately $3.2 million, and the annual operating cost is just over $1.0 million.

Financial Feasibility

To determine financial results, optimal tolls were modeled with the goal of maintaining acceptable traffic performance of the HOV/HOT lanes and efficiency in minimizing total delay, in terms of value of time of all facility users (both HOV/HOT and mixed-flow lanes). The analysis used a simplified toll structure with five toll levels, from the highest during peak traffic periods and negligible tolls during night hours. The analysis was done for years 2002, 2006 (the earliest feasible year for implementation of a southbound HOT lane as a pilot project) and 2025. Options with no intermediate access (Alternative A-3) and one intermediate access (Alternative A-4) were analyzed, as were the 2+ and 3+ carpool policies with both access alternatives. The key peak and average toll level estimates for 2006 (in 2002 dollars) are shown below:

Toll Estimates for 2006 (2002 dollars)

	Alternative A-3 HOV 2+ No intermediate access	Alternative A-3 HOV 3+ No Intermediate access	Alternative A-4 HOV 2+ Intermediate access	Alternative A-4 HOV 3+ Intermediate access
Southbound AM Peak	$3.13	$4.04	$2.87	$4.84
Southbound AM Peak per mile	$0.22	$0.29	$0.20	$0.35
Northbound PM Peak	$4.62	$5.23	$3.52	$5.29
Northbound PM Peak per mile	$0.33	$0.37	$0.25	$0.38
Average toll (both directions, all times of day)	$0.70	$0.83	$0.59	$0.94

The toll estimates (using constant 2002 dollars) were also forecast for years 2002 and 2025. Forecasts for 2006 and 2025 show higher tolls, due to traffic growth in the corridor and the resulting increase in the value of time savings accruing to HOT lane users. The 2006 estimates show peak toll level increases in constant dollars that are, compared to 2002, ranging from 4% to 10%. Year 2025 estimates show peak toll level increases, compared to 2002, ranging from 41% to 75%. The highest toll level in 2025 is $7.06, which is for the southbound AM peak under the HOV 3+ scenario. The toll levels shown by this analysis are clearly within the range of other existing toll roads in the U.S., including other HOT lanes.

From the standpoint of financial feasibility, it is necessary to show that the HOT lanes generate enough gross and net revenue to justify their implementation. To test this, the financial model calculated the annual gross and net revenues and the cumulative present value of the HOT lanes over a 20-year period for each of the alternatives. The years of operation for this analysis were assumed to be 2006-2025. The net income is equal to gross revenue minus expenses for operation and capital replacement.

Gross and Net Revenues (Millions $)

	Alternative A-3 HOV 2+ No intermediate access	Alternative A-3 HOV 3+ No Intermediate access	Alternative A-4 HOV 2+ Intermediate access	Alternative A-4 HOV 3+ Intermediate access
First year gross revenue	9.8	14.1	6.3	14.7
Highest year gross revenue	20.1	27.9	12.3	31.9
Cumulative Present Value of 20-year gross revenue *	159	224	100	245
Cumulative Present Value of Net Income *	142	207	83.0	228

*Based on 4% discount rate assumption.

The overall financial analysis indicates a financially feasible project that would generate substantial net revenues from the opening of the project and steadily increasing net revenues continuing indefinitely. This result is based on conservative assumptions about operating expenses (the most expensive toll collection system) and adopts the MTC forecasting assumption of no assumed inflation-adjusted income growth. If historical trends continue, the assumption of no income growth among users is likely to be an underestimate. If real income actually grows, the real value of time grows accordingly along with the willingness to pay a higher toll. Thus, the gross and net revenue estimates are probably biased downward and are conservative.

Speeds and Travel Times

Under the various scenarios, the average peak-period speeds on the HOV/HOT lanes range from 55 mph to 61 mph, compared to average speeds on the mixed-flow lanes from 25 mph to 34 mph in year 2000. Travel times for HOV/HOT lane users on the corridor segment are reduced by 11 to 19 minutes. By year 2025 traffic congestion worsens, the speeds are reduced and the travel time savings rise dramatically. The average HOV/HOT lane speeds range from 42 to 59 mph, while mixed flow speeds are between 19 and 25 mph. Travel time savings for HOV/HOT users range from 17 to 31 minutes.

Traffic Volumes and Capacity in HOV/HOT Lanes

Travel forecasting for year 2000 shows peak-hour traffic volumes in the HOV/HOT lanes, including both HOVs and toll-paying customers, ranging from 826 to 1362 vehicles per hour (vph), with volumes in most scenarios falling in the 900-1250 vph range. In year 2025 the peak-hour volumes range from 880 to 1783 vph, with volumes in most scenarios falling in the 1000-1500 vph range. Most scenarios show volume well under the recommended maximum of 1600-1700 for an HOV lane, which are fewer vehicles than the recommended 1900-2200 vph for a regular mixed-flow, because there must be an assured higher level of service in the HOV lane. The possible exceedance of the recommended maximum lane volume occurs in one segment of Alternative A-4 and only for the 2+ carpool scenario. This indicates that, by year 2025, either the 2+ carpool policy would have to be reconsidered or tolls for single-occupant vehicles would have to be raised to a level that causes the number of toll-payers to decline.

Since the southbound HOV lane opened in December 2002, Caltrans has conducted frequent traffic counts. The most recent data show peak-hour counts averaging 541 vph in the HOV lane

and 1861 vph in the mixed-flow lanes. Traffic congestion is much less severe and the mixed-flow lane counts are below those for year 2001, which is likely due to the slumping economy and the recent addition of the HOV lane. It is too early to make any judgments about how much capacity would be available for toll-paying vehicles. The long-term planning for the I-680 corridor will proceed on the assumption that the economy will eventually recover and the severe traffic congestion of the late 1990s will recur and worsen.

Operational Analysis

An operational analysis was performed to determine whether a combination HOV/HOT lane is feasible based on traffic operations. Both the HOV-only and the combined HOV/HOT lanes show bottlenecks at the termination of the lanes, where four lanes funnel into three lanes. These constraints can be mitigated and capacity restored by extending mixed-flow auxiliary lanes for short segments (0.5 mile southbound and 1.5 mile northbound), assuming that sufficient right-of-way is available. These mitigations at the termination points are recommended for either an HOV-only or a combined HOV/HOT lane. After the lanes are opened, the volume of vehicles and potential bottlenecks will be closely monitored to determine if and when it is necessary to provide the auxiliary lane.

The combined HOV/HOT lane performs well in most scenarios but results in lower speeds than the HOV-only lane under some scenarios. The reason for lower speeds is the constraint imposed by limited exits from the HOV/HOT lane. Once again, this requires mitigation at the intermediate access location and is, in this case, attributable solely to the HOT lane. The additional capital cost of mitigation for the intermediate access location to alleviate this difficulty with Alternative A-4 is approximately $2.3 million for each direction, or a total of $4.6 million for both directions.

The HOV/HOT lanes have higher person-throughput than do HOV lanes alone, because the remaining available capacity of the HOV lanes can be used by tolled vehicles that would otherwise not be able to have access to it. Properly designed, HOV/HOT lanes appear to be operationally feasible and perform somewhat more effectively than HOV-only lanes in terms of moving people through the corridor. However, the limited access feature of HOT alternatives does remove some of the HOV users who would otherwise use a continuous access HOV lane, because their origin or destination is incompatible with the designated ingress/egress locations.

Policy Considerations

Assuming that I-680 will be widened by two additional lanes, the major decision facing policy-makers is whether to operate these lanes as continuous access HOV-only lanes or as combined HOV/HOT lanes with limited access. There are several types of policy considerations and questions inherent in the choice:

What constitutes “efficiency” in using the new lanes?

- A major objective of a HOT lane is to gain greater efficiency from the capacity added by new lanes. A HOT lane with restricted access allows underutilized capacity to be used by selling it to users who value the time saving and are willing to pay for it. A HOT lane permits more vehicle and person-throughput in the corridor and removes toll-paying vehicles from the mixed-flow lanes. A HOT lane controls the traffic flow in the HOV flow lane by adding access restrictions to the HOV lane (i.e., limited ingress/egress locations) but at the same time allows more vehicles to enter the lane through pricing and thereby makes better use of existing capacity. The number of toll-paying vehicles in the lane can be controlled by adjusting the tolls upward or downward. The restricted access does cause somewhat fewer carpools on the HOV lane, because of the access location limitations. A reduction in the number of carpools is also possible, because some users who would otherwise form carpools would choose to pay a toll instead; however, actual

experience with San Diego's I-15 HOT lanes does not validate this hypothesis. These are issues and trade-offs for policy-makers to take into account.

What is the impact on choices for users?

- A HOT lane clearly provides an additional choice for users, on occasions when saving time is of value to them. On the other hand, a HOT lane system virtually requires limiting access to a few locations, due to toll collection and enforcement considerations. Therefore, the limited access feature – but not the tolling feature – reduces the attractiveness of the lane for carpool users by limiting their ingress/egress choices. While Southern California experience indicates that this is actually not a serious problem, it is a consideration when deciding how to approach I-680. Opinion surveys of HOT lane corridor users in Southern California have indicated that support has grown for the HOT lane concept since they have been in operation.

What is equitable?

- One equity issue sometimes raised in connection with HOT lane proposals is that higher-income individuals will make much greater use of HOT lanes than will lower-income people. While this seems logical, actual experience with existing HOT lanes in Southern California does not bear out that supposition. The income profile of HOT lanes users does not differ greatly from that of the adjacent mixed-flow lanes, though higher-income users do have a propensity to use them somewhat more frequently. Research indicates that low-income individuals place high values of time on some occasions, when being late could be very costly to them. Having the option to pay a toll and be assured reliable time savings can be valuable to persons across the income spectrum. Another equity consideration is making a choice between a direct user fee, paid by a user for making demands on the transportation system during the peak-period, and alternative methods of transportation financing. Some of the other methods, such as sales taxes (unrelated to use of the road) or per-gallon gasoline tax (unrelated to congestion on a facility or to time of day) might be viewed as less equitable than a user toll that varies in relationship to the burden placed on the transportation system.

What are the impacts on HOV lane design?

- The HOT lane scenarios analyzed in this study necessitate minimal changes in HOV lane design. The limited access feature of the HOT lane does require additional striping and possible design exceptions. In the case of the intermediate access (Alternative A-4), it requires mitigation by way of a short additional transition or weaving lane. The overhead electronic toll readers and toll-related signage entail some cost, though very little change in design, because they do not require additional right-of-way or pavement.

Evaluating the Alternatives

The various HOT lane scenarios were evaluated in comparison to an HOV-only alternative and against each other. A summary of the criteria and results follows:

- Corridor travel impacts: All HOT alternatives show definite improvements over HOV-only in terms of person-throughput. The speed data for HOT alternative are mixed, with some scenarios better and some worse than HOV-only. The balance is roughly equal, and it cannot be stated that one or the other has a clear advantage. The same is true with respect to the HOT alternatives compared to one another, except that the 2+ carpool alternatives tended to have higher person-throughput than the 3+ alternatives.
- Operational impacts: The HOT alternatives have slightly negative impacts, due to the limitation of ingress/egress locations and resulting queues at those locations. These impacts can be mitigated with weaving lanes.

- Geometric freeway design: There are no essential design differences among the options, except that the HOT lanes with intermediate access require an additional mitigation lane at the intermediate access location.
- Safety: There is no noteworthy or documentable safety differentiation among the alternatives.
- Tolling and enforcement: This is a mixed result. On the one hand, allowing toll-payers into the HOV lanes complicates visual patrol enforcement by providing two, rather than one, way for a vehicle to be in the lane legally (either as an HOV or a toll-payer). However, with the aid of an electronic signal to indicate a toll has been collected, the enhanced patrol and video surveillance paid for by the toll revenue, and the deterrent to violation by giving potential HOV lane violators the option to pay a small toll rather than risking an expensive fine, enforcement should be improved, On balance, HOT alternatives are a plus on the enforcement criterion, though not without complication. Among HOT alternatives, those with no intermediate access are somewhat easier to enforce.
- Travel options: All HOT lane alternatives have a clear advantage over HOV-only, because they provide a new option – pay a toll to avoid delay—not otherwise available. The A-4 alternative with intermediate access is somewhat better on this criterion, because it provides additional flexibility. However, the limited access feature of all HOT alternatives does reduce the number of HOVs that might otherwise use an unlimited access HOV-only facility.
- Capital cost: The HOT alternatives each have a moderately higher cost than HOV-only. In the context of the entire widening project these are not high costs: $4.6 for intermediate access and $3.2 million for toll collection equipment. Nevertheless, these costs would have to be funded.
- Revenue generation: HOT lanes are clearly superior to HOV-only lanes, which generate no revenue. The various HOT lane scenarios generate between $6.3 and $14.7 million in the first year, between $12.3 and $31.9 million by the twentieth year, and continue to produce revenue for the full life of the facility. The HOT alternatives with the 3+ carpool policies produce considerably more revenue than the 2+ carpool scenarios, and the A-4 scenario with intermediate access produces somewhat more revenue than A-3 with no intermediate access.
- Net operating income: Once again, HOT lanes generate a positive income stream from the first year, escalating rapidly thereafter, while HOV-only lanes generate no income. The cumulative net income over 20 years ranges from $83 million to $228 million and, as with gross revenue, the 3+ carpool policies generate much higher revenue, and the A-4 alternative with intermediate access generates somewhat more revenue than A-3 with no intermediate access.
- Equity: Because equity is subject to numerous definitions, this criterion yields mixed results. From the income distribution standpoint, the more affluent drivers can afford to pay a toll more easily than the less affluent. On the other hand, HOT lanes provide an option for all potential users and only those enjoying the benefit will pay. Furthermore, if revenues are used to improve transit service in the corridor, it makes more transit available to others, including those with lower incomes.
- Transit impact: HOT alternatives have the potential to fund transit service, so they are superior to HOV-only. The only potential negative for transit would be if too many toll-payers were allowed on the HOV/HOT lane and slowed bus service. However, this possibility can be easily avoided by adjusting tolls upward to reduce usage.

Conclusions

1. The travel demand model forecasts that adequate capacity on I-680 exists to sustain HOV/HOT lanes as a viable alternative. All near-term scenarios indicate that there will be capacity to allow at least several hundred additional vehicles to “buy into” the planned HOV lanes.

2. I-680 HOT lanes are financially feasible. HOT lanes generate revenue that more than covers the cost of operations, and most scenarios generate substantial excess revenues.

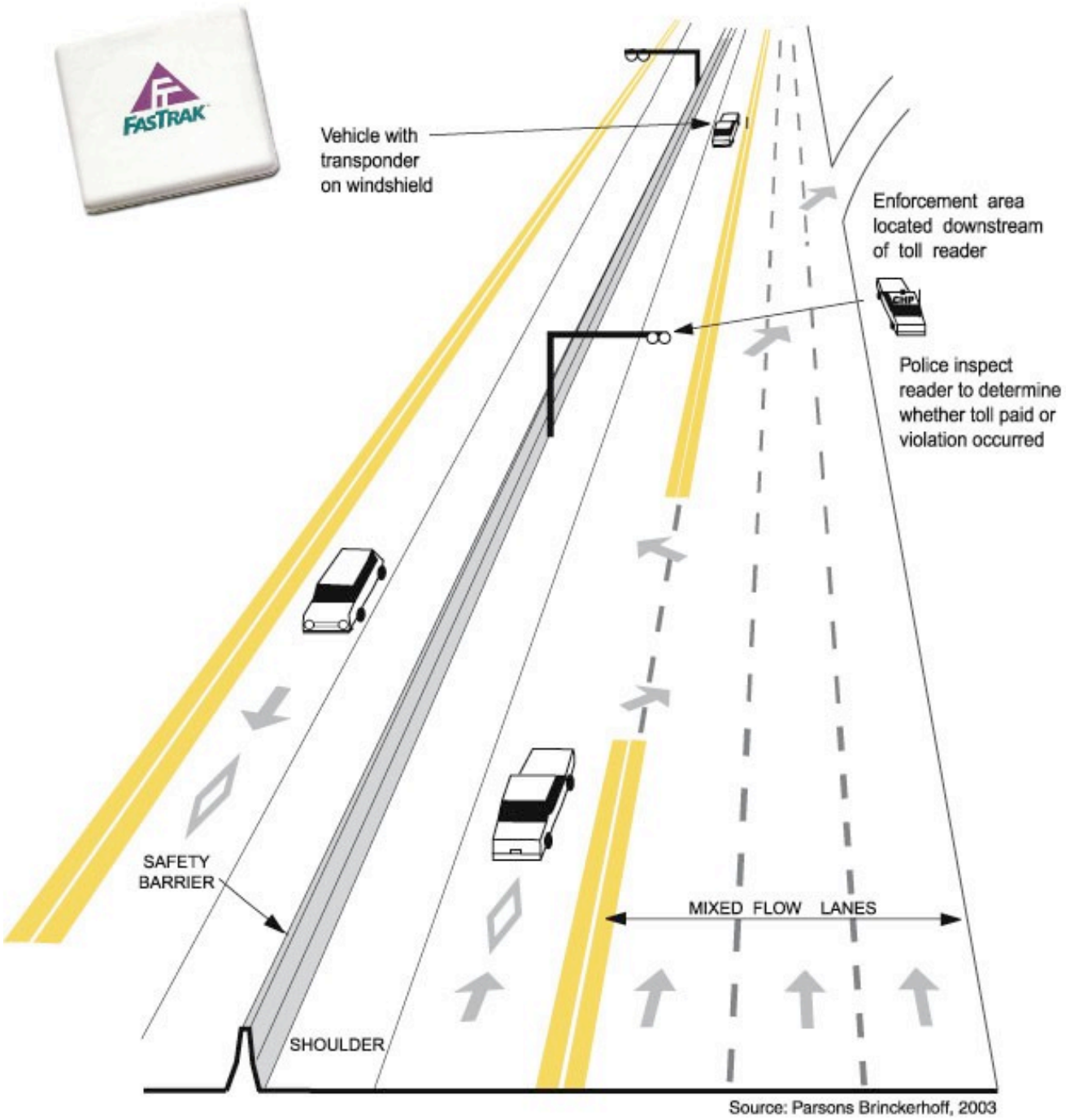
3. I-680 HOT lanes are operationally feasible. Combined HOV/HOT lanes can be operated in a manner that maintains smooth and congestion-free traffic flow on the HOV/HOT lanes without impairing the functioning of adjacent mixed-flow lanes. Potential negative impacts can be largely mitigated by adding transition or weaving lanes, at the ingress and egress points of the HOV/HOT lanes. Further coordination with Caltrans and the California Highway Patrol will be done to assure operational feasibility.

4. HOT lanes are compatible with HOV lane operations. Toll levels can be adjusted upward or downward as usage warrants to always assure a high level of service in the HOV/HOT lane. However, the limited access feature does create a complication for HOV users, because they are limited in the locations where they can get on or off the HOV lane.

5. Enforcement can be maintained at a reasonably high level. A striped lane separation, while less effective than a solid physical barrier, could be well enforced with enhanced highway patrol and electronic collection and surveillance. The study finds that enforcement is likely to be much more effective than the current enforcement of unlimited access HOV lanes. There must be further coordination with the California Highway Patrol to assure adequate enforcement.

6. HOT lanes can be implemented with flexibility. With the striped lane separation, it is relatively easy change the location, number, and configuration of ingress/egress points for the HOV/HOT lanes. If begun as a pilot project in the southbound direction, several options could be evaluated, tested and modified as necessary.

7. Implementation faces major challenges. There are numerous institutional challenges to be addressed before a HOT lane system can be applied to I-680. The concept is new for Bay Area decision-makers and will require interagency cooperation on legal, financial, and operational issues. Specific state legislation will be necessary to authorize the charging of tolls and implementation of HOT lanes on this freeway.



Proposed HOT Lanes Freeway Configuration